1.1.1.1.1.7 Chapter 8

8. Flight computer

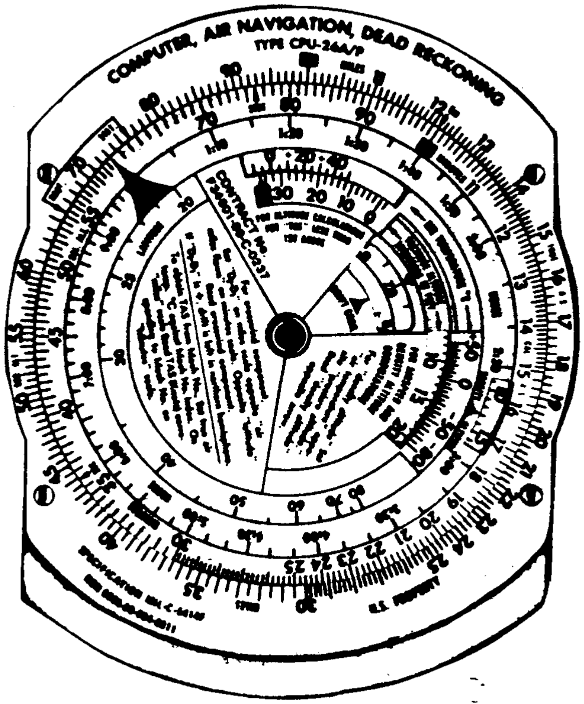

Figure 8-1

This chapter will briefly introduce the operation of the “slide rule” face of the flight computer, known by many fliers as the “whiz wheel”. It’s a time-proven tool that has a variety of uses. Some pilots prefer special electronic calculators that can accomplish the same functions as whiz wheels, but others prefer the wheel’s simplicity.

The flight computer’s primary advantage is that it’s not dependent upon any source of electrical power, like battery- or solar-powered calculators. It can be used at night, on cloudy days, or bright sunny days with equal accuracy. Its primary disadvantage is that the user must mentally keep track of the decimal point. It’s not uncommon for the new user to calculate wrong by a factor of 10. But, with experience such errors become less common. The whole slide rule face is pictured in Figure 8-1. The wind face of the computer is on the other side and will not be covered in this text.

The computer side of the flight computer has 3 concentric scales that go all the way around the wheel. The outside one is on the stationary part, and the other two are on the rotating wheel. For sake of this discussion, the scales will be referred to as the outer, middle and inner scales. It also includes a number of other features including an assortment of windows and indexes. The most important other feature is the large triangle-shaped *rate index*. Refer to Figure 8-2 and locate the 3 scales and the rate index.

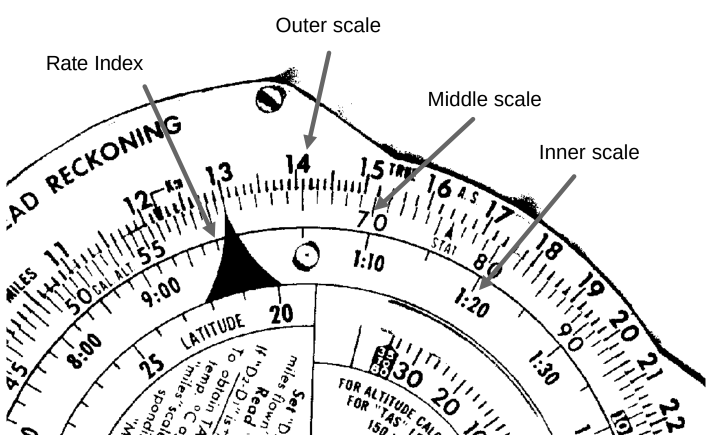

Figure 8-2

The other side of the computer is referred to as the “wind face.” There is a rotating part with a plastic window, a scale on the fixed frame along with the true index, and a sliding panel with curved lines.

The flight computer is most commonly used to solve rate problems. In its simplest form a rate problem consists of three variables—rate, time, and units. The “units” may be anything that you work with over a period of time, but the most common in aviation are miles of distance and gallons of gasoline. The “units” part

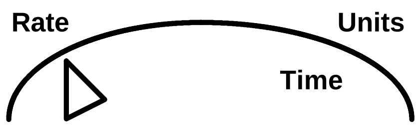

Figure 8-3

of the problem may be expressed in any measurement as long as the “rate” portion is expressed in the same units. For instance, if you are solving a problem involving nautical miles, the rate must be expressed in terms of nautical miles per hour or knots. The rate must be expressed in units/hour, and the time must be expressed in minutes to use the middle scale.

All rate problems are set up on the flight computer as seen in Figure 8-3. The rate on the outer scale is matched with the rate index on the middle scale, and the units on the outer scale are matched with the time on the middle scale. Just rotate the moveable wheel and use the two known variables to find the third one. Here’s some examples using miles, miles-per-hour (mph), and time:

8.1 Speed

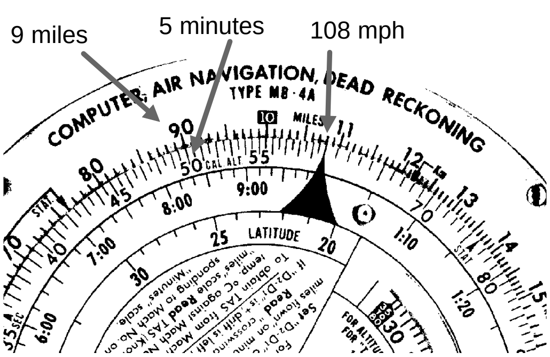

Figure 8-4

You flew the first nine miles of a trip in five minutes. What is your average ground speed?

Study Figure 8-4 for the solution to this problem. Rotate the inner disk until five minutes (on the middle scale) is directly beneath nine miles (on the outer scale). Then look to the number on the outer scale directly opposite the triangular rate index. You can see that the index points to the eighth line between ten and eleven. What number does this represent? As stated earlier, the wheel’s primary disadvantage is that the user has to mentally keep track of the decimal point position. In this problem, if you had flown ten miles in five minutes, your ground speed would be exactly two miles per minute or 120 mph. You didn’t quite fly ten miles, but your answer should be close to 120 knots. The eighth line between ten and eleven in this problem thus equals 108 knots.

8.2 Time

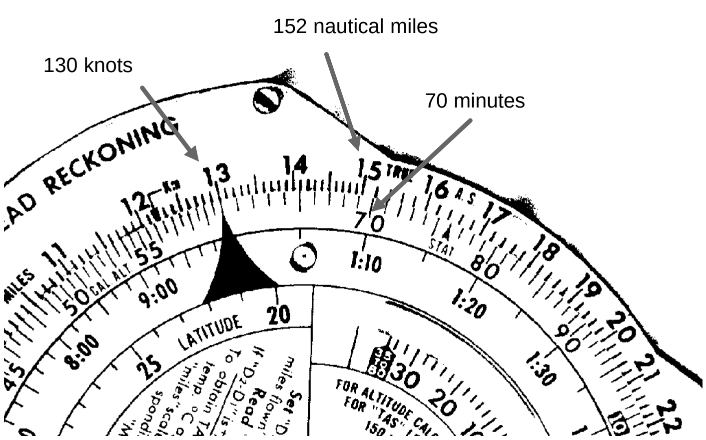

Figure 8-5

During flight planning, you calculate a ground speed of 130 knots. How long will it take you to fly 152 miles at that speed?

This is similar to the last problem except it’s worked in reverse. Start by lining up the rate index (on the movable disk) with 130 on the miles scale as shown in Figure 8-5. Then look along the outer scale (representing miles) until you find the distance you plan to fly -- 152 miles. Directly under 152 is the answer, 70 minutes.

Notice that immediately beneath 70 on the middle scale is 1:10 on the inner scale. The computer’s designer included this feature to help the user convert minutes into hours and minutes. In this problem, the solution is apparent -- 70 minutes equals one hour and ten minutes. When dealing with larger numbers, the solutions are not so apparent, and you’ll appreciate the convenience of this extra scale.

8.3 Distance

On the same flight with a ground speed of 130 mph, how far can you fly in one hour and 30 minutes? With the rate index still set on 130 mph, locate one hour and 30 minutes on the inner scale and you will find that corresponds to 90 minutes on the middle scale (Figure 8-5). Now read the answer of 195 miles on the outer scale just above 90 minutes.

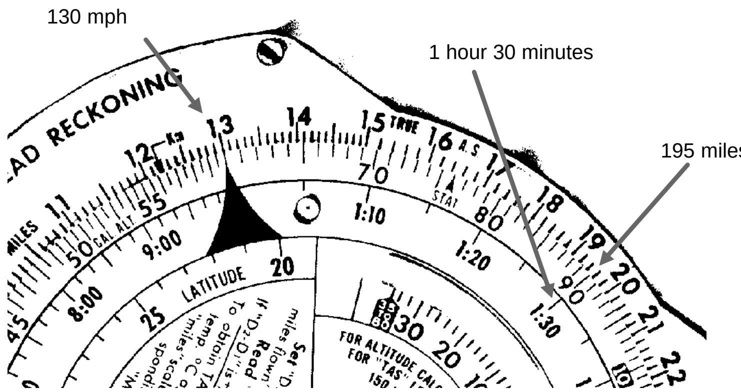

Figure 8-5

All three of the problems just covered were set up on the computer in the same way using rate, miles and time. The only difference is that you have to work with the two known variables to obtain the third one.

8.4 Scales

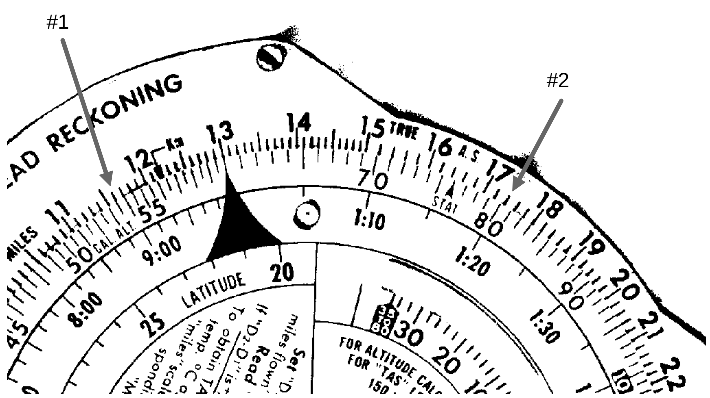

Figure 8-6

Now that you have tried a couple of problems, you’ve probably noticed something about the computer that can be very confusing – the marks on the scales do not always represent one mile or minute. Depending on where you are on the scale, a mark may represent 1, 2, 5 or even more. The best way to read a number on a scale is to refer to the nearest labeled marks and determine what each mark represents before deciding on the answer. For example, #1 in Figure 8-6 is pointing to 116 (or 11.6 or 1.16, etc.). When reading this number, you should look at eleven on the left, and 12 on the right. Then, you can see that each mark represents “1” and determine that the answer is 116. On the other hand, even though #2 in the same figure points to two marks right of 17, it is ***not*** pointing to 172. Look at 17 on the left and 18 on the right, and you will see that each tick mark represents “2” and the answer is 174. Other than misplacing the decimal, determining the correct units before reading an answer is the greatest source of error in using the flight computer.

8.5 Fuel

During mission planning, you determine from the airplane operating handbook that you will use 9.6 gallons of fuel each hour. How much fuel will you use on a mission expected to take six hours and ten minutes?

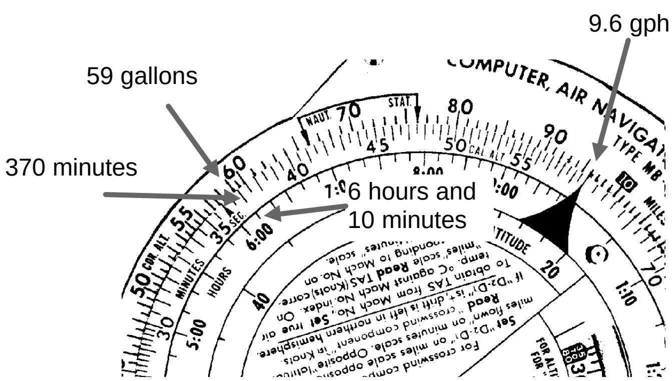

Figure 8-7

To solve this problem, the outer scale is still used to represent units, but it is gallons instead of miles. Start by lining up the rate index with the 9.6 gallon-per-hour fuel burn rate as shown in Figure 8-7. Find the time of 370 minutes on the middle scale and read the answer of 59 gallons on the outer scale. This is a good opportunity to use the inner scale to convert from hours and minutes to minutes. Six hours and 10 minutes is located on the inner scale next to 370 minutes on the middle scale. Look on the middle scale to the left of the number opposite 370 minutes (or 6:10 on the hours and minutes scale) and find the solution of slightly over 59 gallons.

8.6 Nautical and statue miles

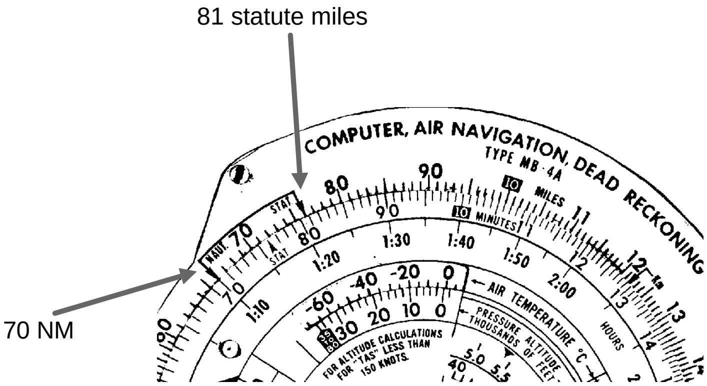

Figure 8-8

You can also use the flight computer to convert back and forth between nautical miles and statute miles. There are two connected arrows on either side of the "70" on the outer scale. The arrow on the left is labeled "NAUT" for nautical, and the arrow on the right is labeled "STAT" for statute. To convert from nautical to statute, place the nautical miles under the "NAUT" arrow and read the answer under the "STAT" arrow. To convert from statute to nautical, place the statute miles under the "STAT" arrow and read the answer under the "NAUT" arrow. Figure 8-8 shows that 70 nautical miles equals about 81 statute miles. This also works with speeds—70 knots is approximately equal to 81 miles per hour.

8.7 True airspeed

Airspeed indicators measure how fast the aircraft is moving through the air, and they are very accurate at low altitudes. However, at higher altitudes, there can be a significant difference between indicated airspeed (the number on the instrument) and true airspeed. You can use the flight computer to correct for this error. An airspeed indicator may be affected by the way it is installed in an aircraft, but that error is usually very small. Adjusting indicated airspeed for installation error yields calibrated airspeed. The difference is usually so small that calibrated airspeed is considered equal to indicated airspeed. But, to get from calibrated to true airspeed, the flight computer is used to make adjustments for altitude and temperature. For example, if you are flying at 12,000 feet where the temperature is -10° C with a calibrated airspeed of 145 mph, your true airspeed would be 173 mph. Figure 8-9 shows how to line up the altitude and temperature in the inner window, then read the true airspeed on the

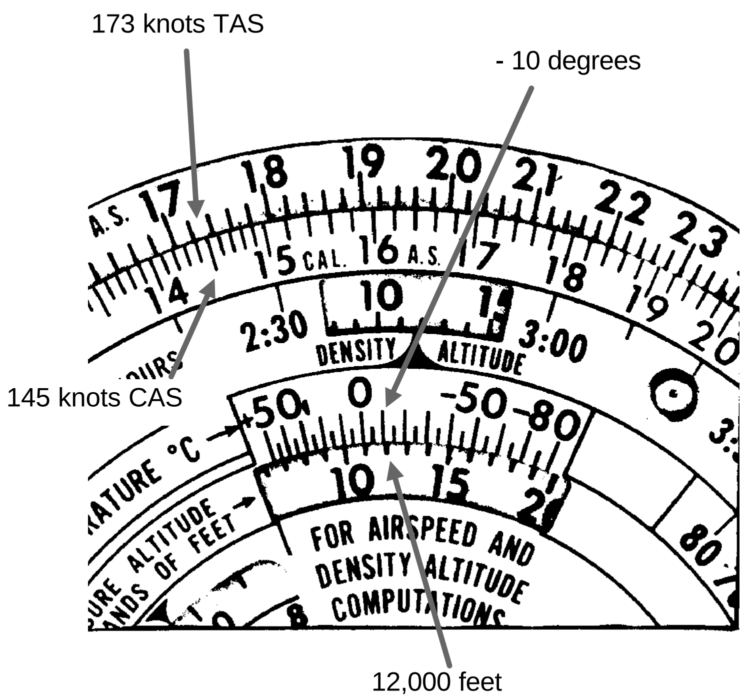

Figure 8-9

outer scale opposite the calibrated airspeed on the middle scale. On the temperature scale, notice the location of +50 and -50. That scale is reversed, so make sure you are on the correct side of zero when lining up the temperature and altitude.

8.8 The wind face

8.8.1 Frame and Compass Rose

The other side of the flight computer is primarily used to solve problems concerning wind. The frame has a reference mark called the TRUE INDEX and a drift correction scale on each side of the true index. The transparent disc, with the compass rose, rotates so you can set any direction under the true index. The center of the transparent disc has a small black circle called the GROMMET.

8.8.2 The Slide

Each side (low speed, high speed) of the slide has a portion of a circular graph printed on it. The values of each circle vary with the side. The low speed side of the slide is marked from 0 to 275, while the high-speed side is marked from 60 to 840. When the slide is inserted in the frame, the centerline lies beneath the true index and the grommet. There are lines on each side of the centerline, which radiate from the origin of the circular graph (off the slide on the high-speed side). On the low speed side, these lines are spaced at five degrees up to the 30-unit circle, at two degrees up to the 150-unit circle and at one degree the remainder of the slide.

If you picture the wind triangle superimposed upon the computer slide, it will enhance your understanding of the mechanical solutions you perform on the wind face of the computer. Notice that the arcs represent speed and the radiating lines represent drift correction. Consequently, by adding or subtracting drift correction -- the angle between the ground vector and the air vector -- you'll find your aircraft heading.

The preflight wind problem is one of many types of wind problems you'll solve with the DR computer. It is the one most commonly used by pilots and the one we will discuss. Throughout the discussion of the wind triangle, the wind vector will have both direction and speed. In future discussions it may be referred to as WV. This term is commonly used for wind speed coupled with wind direction. Before explaining the mechanics of the preflight wind triangle on the computer, you need to determine what kind of direction we're going to use. You must be consistent and use either magnetic or true direction throughout the problem.

TC + VAR = MC

MC + DC = MH

TC + VAR + DC = MH

Since DC in the formula is the difference between MC and MH we use magnetic direction. This means that MC is always read under the true index, and it also means the wind information received from the weather forecaster must be converted to magnetic direction. MH is always the result of applying DC to MC. The resultant wind triangle is composed of the following: Magnetic WV, MC and TAS, MH and groundspeed (GS). Of these components, magnetic WV, MC and TAS are known quantities. Use the computer to determine MH and GS.

Example 1: With the following information given, solve for MH and GS:

MAG WV - 300 degrees/40 knots

MC - 055 degrees

TAS - 435 knots

Solution: Determine which side of the slide to use. Since the TAS is 435 knots, use the high-speed side. Now, apply the wind to the computer by rotating the compass rose to place the magnetic direction of the wind under the true index. Next, place the grommet under any convenient speed circle, such as the 300- unit circle, and count up the number of increments equal to the speed of the wind. (This is the wind up method used by pilots.) Be sure to interpolate properly. At this point, make a small dot or tee (T) on the face of the computer.

Now, rotate the compass rose to place the MC, 055 degrees, under the true index, and move the computer slide until the dot or tee is over the speed line representing the TAS of 435 knots. Read the answer for GS under the grommet. GS = 450 knots. Determine the DC under the wind dot (five degrees), and apply it to the MC for MH of 050 degrees. The wind dot is five degrees to the left of the centerline, MH is found on the compass rose five degrees to the left of the true index along the drift correction scale, or a minus five degrees. If the wind dot is to the right of the centerline, MH is the same number of degrees on the compass rose to the right of the true index along the drift correction scale, or a plus number of degrees.

Example 2: Solve the following preflight problem:

Mag WV = 2450, MC 290 degrees, TAS = 220 knots

Solve for: MH and GS

Solution: Since the TAS is relatively low, use the low speed side of the slide. Set the magnetic wind direction under the true index. Place the grommet on a speed circle, count up to 50 knots for the wind velocity and make a pencil mark. Now rotate the compass rose until the MC of 290 degrees is under the true index. Set the pencil mark on the 220 (TAS) speed line and read the GS (185) under the grommet. The DC is under the pencil mark (-10 degrees) and should be applied to the MC to get a MH of 280 degrees.

Example 3:

TAS = 210 knots, TC=250 degrees, WV=0965, VAR=10 degrees W

Solve for: MH and GS

Answer: The TAS would fit on the low side, but you discovered you had to switch to the high-speed side because of the wind. Slight differences in computers can easily result in a two degree difference in DC in the above problem, hence the $\pm$ 2 degree tolerance. Normally, your answers on the high-speed side should be within $\pm$ 1 degree and $\pm$ 3 knots. Your answers should be MH = 255 degrees, GS = 268 knots.

8.8.3 Review

These next few paragraphs will review what we've learned in this unit. The variation angle is the difference between a true direction and a magnetic direction. The drift correction angle is the difference between a course and a heading.

On the wind face of the computer, your pencil mark indicates the direction and speed of the wind. The wind direction you obtained from the forecaster is based on true north. Therefore, be sure to add or subtract variation before you solve wind problems.

- Draw the Mag WV on the wind face side.
- Rotate the movable scale to place the MC under the index.
- Always place the penciled “T” on the speed line equal to TAS (T for true).
- Under the grommet you always find GS.
- The penciled mark appears on or near a heading line that indicates the degrees of DC. If the penciled mark is on the left, the DC is a minus DC; with a plus DC you add the DC angle to MC to determine MH.

8.8.4 Resolving a wind into its headwind component

In some preflight planning, the pilot must use a headwind component of a prevailing wind condition to determine the cruise power and fuel requirements. In aircraft with critical wind limitations for landings, the aircrew checklist usually includes a chart to break down the wind into its components. Unfortunately, these charts are limited to normal landing wind velocities, which are a fraction of the wind you encounter at altitude. To solve cruise problems, the wind face of the computer is the most expeditious means-both for preflight and in-flight problems.

You're planning to fly a long flight on a MC of 310 degrees with a prevailing wind of 280/80, and with a ten-degree easterly variation. To determine your best cruise TAS and fuel flow, you need to resolve the wind into its components.

There's a rectangular grid system with two scales at the bottom of the high-speed side of the slide. The left-side scale is marked off in increments of ten units per block and is used for large vector breakdowns, primarily above 60 knots. The right-side scale is marked off in three units per block and used for below 60 knots vectors. Choose your scale based on wind velocity. In this problem the high-speed scale is used, so slide it under the wind face compass rose.

The wind face true index is used as in a groundspeed problem, so rotate the compass rose until the magnetic wind is under the index (280 degrees-10 degrees = 270 degrees). Next, place the grommet over the wind velocity and draw a line from the “0” baseline to the grommet, representing the wind and its velocity. Now rotate the compass to your desired magnetic course (310 degrees) and slide the tail of the wind vector pencil line to the baseline and read the headwind component (65) under the grommet as shown. This is your headwind component for this wind and would be used in your preflight planning with the performance data charts to obtain the maximum range true airspeed.

Example 1:

True WV - 060/75

VAR - 10 degrees west

MC - 030 degrees

Answer: 060 degrees+10 degrees (west variation) = 070 degrees magnetic wind. Set 070 degrees under the true index and place the grommet over 75 on the center scale. Rotate the compass rose until the MC of the 030 degrees is under the true index then place the pencil mark on the baseline as shown on the illustration. The headwind component of the wind (55 knots) is under the grommet.

8.8.5 Proceeding directly to a DME fix

There are times when you'll be required to travel directly to a radial/DME. Your DR computer provides a quick and accurate method of computing a course and distance from one DME fix to another. You can use the DR computer for this both before and during flight.

Example problem: You're at point A, 100 NM out on the 090 degrees radial. You've just been cleared to go directly to point B, which is 80 NM out on the 180 degrees radial. What's the no-wind heading you'll fly to get to point B?

For the solution, follow these steps:

- Place the square grid portion of the computer slide under the wind face.
- The grommet always represents the station.
- Place the radial of your present position (090) under the true index.
- Place a dot, with a circle around it, 100 NM up from the grommet. (Be sure to use the graduated scale on the grid for distance.) This represents your position relative to the station.
- Place the radial of the fix to which you're going (180 degrees) under the true index.
- Place a dot 80 NM up from the grommet to represent point B.
- Rotate the compass rose to align the dots vertically making sure the dot with the circle (your position) is toward the bottom.
- The heading beneath the true index is your no wind heading to your new fix (231 degrees).
- Draw a line connecting the two dots. This represents your course and gives you a picture of your course relative to the station.
- To check your progress, place the radial you're crossing under the true index and compare the actual distance from the station with the desired distance on the computer.
- If you're off course you can make a correction. What should your distance from the station be when passing the 140 degrees radial?

Answer: 62 NM.

Example problem: Compute flight plan information for the following:

KNOWN		COMPUTE:	
Distance	200 nm	True Air Speed (TAS)	(2)
Course (TC)	270	Drift Correction (DC)	(3,4,5,6)
Variation	15 East	True Heading (TH)	(7)
Altitude	5,500 ft.	Magnetic Heading (MH)	(8)
Temperature	56F	Ground Speed (GS)	(9)
Calibrated Air Speed(CAS)	140mph (1)	Estimated Time Enroute (ETE)	(10)
Wind/Velocity	330 at 25 knots(330/25)	Estimated Fuel Use	(11)
Fuel Consumption	11 gal/hr		

Solution:

- (1) Convert all information into common units—either statute or nautical

  Place statute information (140 mph) opposite STAT arrow.

  Read nautical information opposite NAUT arrow - 122 knots

- (2) Compute TAS - Convert temperature to C if needed - 56° F = 13° C.

  56-32 = 24

  24/9 = 2.66

  2.66X5 = 13°C

  (Remember accuracy is only 2 digits)

  Set TEMP (56° F or 13° C) on rotating face opposite ALT (5.5) in the window

  Find CAS (122 knots) on MINUTES scale

  Read TAS on MILES scale..........133 knots

- (3) PUT W/V ON COMPUTER

  Position wind DIRECTION (330) on compass rose opposite TRUE INDEX

  Draw VELOCITY vector over centerline FROM grommet TOWARD True Index

  (Note the vector length, 25 units = wind velocity of 25 knots)

- (4) TURN COMPASS ROSE UNTIL TC IS UNDER TRUE INDEX Position 270 under TRUE INDEX

- (5) MOVE SLIDE UNTIL TAS IS UNDER TAIL OF WIND VECTOR 135 knots under TAIL of wind vector

- (6) READ DRIFT CORRECTION UNDER TAIL OF WIND VECTOR.- 9 right

- (7) COMPUTE TH (= TC +R or -L DC) - 270 + 90 = 279
- (8) COMPUTE MH (= TH +W or -E Var) 279 - 150 = 264
- (9) READ GS UNDER GROMMET - 120 knots
- (10) COMPUTE ETE FROM GS AND DIST

  Set INDEX on compass rose opposite GS (120)

  Read ETE on HOURS scale opposite DIST on MILES scale - 1:40
- (11) COMPUTE ESTIMATED FUEL USE

  Set INDEX on compass rose opposite FUEL CONSUMPTION (11 gal/hr)

  Read FUEL USE on MILES scale opposite ETE on HOURS scale - 18.2 gals
- (12) COMPUTE FLIGHT TIME AVAILABLE

  Set INDEX on compass rose opposite FUEL CONSUMPTION (11 gal/hr)

  Read FLIGHT TIME on HOURS scale opposite FUEL ON BOARD on MILES scale - 4:33